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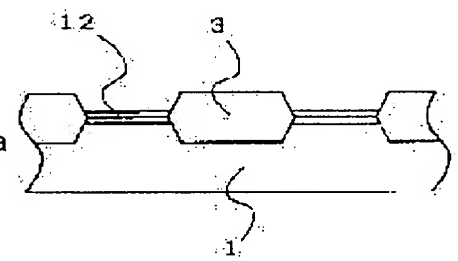
(54) METHOD OF MANUFACTURING SEMICONDUCTOR CRYSTAL GRAIN OR THIN FILM

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a manufacturing method by which a single-crystal thin film of large-diameter diamonds, silicon carbide, and gallium nitride containing less defects can be grown.
SOLUTION: After a nitride film formed on a single-crystal silicon substrate is patterned, the substrate is oxidized by using the nitride film as a mask. Since bird's beaks are formed in the formed oxidized film, a semiconductor area which is patterned smaller than the nitride film can be formed. Then semiconductor crystals are precipitated in the semiconductor area by making a current flow to the semiconductor area, by applying a bias voltage across the silicon substrate and an electrode set up oppositely to the substrate. Single- crystal grains or a thin film of diamond, etc., is formed by performing epitaxial grown by using the semiconductor crystals as nucleus.



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CLAIMS BEST AVAILABLE COPY

[Claim(s)]

[Claim 1] The process which forms the nitride by which patterning was carried out on a single crystal silicon substrate, The process which oxidizes said single crystal silicon substrate exposed as a mask using this nitride, and forms a silicon oxide in a part of silicon semi-conductor substrate front face, The process which forms the semiconductor region which removed said nitride, was made to expose said single crystal silicon substrate surface, and was divided with said silicon oxide, By impressing bias voltage to inter-electrode [which countered said single crystal silicon substrate and this substrate, and was installed in the plasma ambient atmosphere], and passing a current to said divided semiconductor region The manufacture approach of of the semi-conductor crystal grain or the thin film characterized by including the process which deposits a semiconducting crystal on this semiconductor region, and the process into which the semiconducting crystal which this deposited is grown up.

[Claim 2] The semiconductor region divided with said silicon oxide in the manufacture approach of semi-conductor crystal grain according to claim 1 or a thin film is the manufacture approach of of the semi-conductor crystal grain or the thin film which considers as the crevice configuration which makes a pars basilaris ossis occipitalis said semiconductor region, and uses a side face as said silicon oxide, and is characterized by depositing said semiconducting crystal on the semiconductor region of this pars basilaris ossis occipitalis.

[Claim 3] The manufacture approach of of the semi-conductor crystal grain or the thin film with which claim 1 or said semiconducting crystal which deposits is characterized by being a diamond, silicon carbide, or gallium phosphorus in the semi-conductor crystal grain of a publication, or the manufacture approach of a thin film 2 either.

[Claim 4] Claim 1 or said bias voltage impressed [in / 2 either / the semi-conductor crystal grain of a publication or the manufacture approach of a thin film] is the manufacture approach of of the semi-conductor crystal grain or the thin film characterized by being either of the pulse voltages which repeat a direct current, a pulsating flow, an alternating current, or positive/negative by turns.

[Claim 5] The manufacture approach of of the semi-conductor crystal grain or the thin film characterized by overlapping said bias voltage which consists of a pulse voltage which repeats a pulsating flow, an alternating current, or positive/negative by turns in the manufacture approach of semi-conductor crystal grain according to claim 4 or a thin film on direct-current bias voltage.

[Claim 6] The manufacture approach of of the semi-conductor crystal grain or the thin film characterized by including claim 1 or the process which forms the semiconducting crystal, the crystal grain, or the thin film of gallium phosphorus selectively on said

semiconductor region, and the process which some [at least] Lynn of this gallium phosphorus is permuted [process] by nitrogen, and deposits the crystal grain or the thin film of gallium nitride on the semiconducting crystal of said gallium phosphorus, crystal grain, or a thin film in the semi-conductor crystal grain of a publication, or the manufacture approach of a thin film 2 either.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] Especially this invention relates to the manufacture approach of a diamond, silicon carbide, gallium phosphorus, the single crystal grain of gallium nitride, or a single crystal thin film about the manufacture approach of semi-conductor crystal grain or a thin film.
[0002]
[Description of the Prior Art] Wideband gap semi-conductors, such as a diamond, and gallium nitride (GaN), silicon carbide (SiC), attract attention as electronic ingredients, such as a device for environments-proof, and a power device, from physical-properties values, such as dielectric-breakdown electric field, electronic mobility, and the melting point. However, production of a single crystal substrate is difficult for any ingredient, and it has been the failure of utilization.
[0003] For example, the crystal growth of a diamond has the common heteroepitaxial growth method for depositing a crystal with a microwave plasma-CVD method or a hot filament grown method on substrates, such as silicon (Si), platinum (Pt), iridium (Ir), and copper (Cu). However, since gap of the lattice constant of a substrate and a diamond crystal and the difference of a coefficient of thermal expansion were large, the diamond thin film formed by such approach had the trouble that there were many defects.
[0004] Moreover, when forming a diamond thin film, for example on the substrate of the diameter of macrostomia by the microwave plasma-CVD method, a thin film 23 is formed by making substrate 2 front face generate the nucleus 22 of many diamonds (drawing 13 a), and making it carry out epitaxial growth (drawing 13 b). Since the crystal orientation of the nucleus to generate is in agreement with the crystal orientation of a substrate, if field bearing of a front face uses the single crystal silicon of (111) as a substrate, the nucleus of the diamond which has field bearing of (111) will generate it. If growth is furthermore continued, the diamond of (111) can grow so that a substrate front face may be covered, and can grow up a thin film.

[0005] Here, it can be dramatically difficult to control an origination-of-nucleus consistency, and it cannot grow up a crystal into a desired location. Moreover, when forming a thin film and the origination-of-nucleus consistency was high, the single crystal thin film which grew from each nucleus accumulated, and there was a problem of becoming the polycrystal film.

[0006] On the other hand, as an approach by which the single crystal thin film of high quality is obtained, the homoepitaxial grown method which forms the epitaxial growth film on a diamond substrate is reported. However, this approach had the trouble that a substrate was expensive.

[0007] Thus, in the conventional diamond grown method, the single crystal grain was formed in the desired location, and there was a trouble that it was very difficult to obtain a single crystal thin film with few defects.

[0008] Since it does not have the melting point by ordinary pressure in the case of silicon carbide (SiC), production of the single crystal substrate by liquid phase epitaxy is difficult, and the growth approach called the so-called sublimating method is adopted.

[0009] However, by the sublimating method, crystal aperture does not expand the magnitude of the single crystal which grows on a seed crystal side with extent which becomes large slightly from seed crystal. On the other hand, in order to use the single crystal in which seed crystal was also formed by the sublimating method etc., seed crystal of the diameter of macrostomia could not be obtained, but there was a trouble that diameter-ization of macrostomia of a substrate could not be achieved from this point, either.

[0010] Moreover, although it was also known that cubic silicon carbide will grow on a single crystal silicon substrate by the sublimating method, when silicon carbide was grown up all over the substrate, the crystal with which approaching field bearing shifted is in the middle of growth, and there was a trouble that only overlap and the polycrystal film were obtained.

[0011] Thus, in the grown method of the conventional silicon carbide, there was a trouble that the single crystal thin film of the diameter of macrostomia could not be obtained. Moreover, there was a trouble that a single crystal thin film could not be obtained.

[0012] On the other hand, it becomes possible to reduce the defect density in the film of gallium nitride conventionally using the crystal growth method called lateral overgrowth to up to a sapphire (aluminum 2O3) substrate, and development of an electron device is progressing quickly. However, since gap of the lattice constant of silicon on sapphire and a gallium nitride crystal and the difference of a coefficient of thermal expansion were large even if it used this technique, the defect under crystal had the trouble that there were many defects, about [107 //cm] two as compared with semi-conductors, such as a ****, silicon, and GaAs.

[0013]

[Problem(s) to be Solved by the Invention] By the manufacture approach of the conventional thin film, there was a trouble that the single crystal thin film of the diameter of macrostomia was not obtained, as mentioned above. Moreover, there was a trouble that a single crystal thin film with few defects was not obtained. This invention cancels the above-mentioned trouble and it aims at offering the manufacture approach of the crystal grain into which the diamond of the diameter of macrostomia, silicon carbide, and the single crystal thin film of gallium nitride can be grown up, or a single crystal thin film. Moreover, it aims at offering the manufacture approach of the crystal

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grain into which a single crystal thin film with few defects can be grown up, or a single crystal thin film. Furthermore, it aims at offering the manufacture approach of the crystal grain into which the single crystal thin film of gallium phosphorus used in order to grow up the single crystal thin film of the above-mentioned gallium nitride can be grown up, or a single crystal thin film.
[0014]
[Means for Solving the Problem] In order to attain the above-mentioned object, the invention in this application concerning claim 1 The process which forms the nitride by which patterning was carried out on a single crystal silicon substrate, The process which oxidizes said single crystal silicon substrate exposed as a mask using this nitride, and forms a silicon oxide in a part of silicon semi-conductor substrate front face, The process which forms the semiconductor region which removed said nitride, was made to expose said single crystal silicon substrate surface, and was divided with said silicon oxide, By impressing bias voltage to inter-electrode [which countered said single crystal silicon substrate and this substrate, and was installed in the plasma ambient atmosphere], and passing a current to said divided semiconductor region It is characterized by including the process which deposits a semiconducting crystal on this semiconductor region, and the process into which the semiconducting crystal which this deposited is grown up.
[0015] The semiconductor region where the invention in this application concerning claim 2 was divided with said silicon oxide in the manufacture approach of semi-conductor crystal grain according to claim 1 or a thin film is made into the crevice configuration which makes a pars basilaris ossis occipitalis said semiconductor region, and uses a side face as said silicon oxide, and is characterized by depositing said semiconducting crystal on the semiconductor region of this pars basilaris ossis occipitalis.
[0016] The invention in this application concerning claim 3 is characterized by above-mentioned claim 1 or said semiconducting crystal which deposits being a diamond, silicon carbide, or gallium phosphorus in the semi-conductor crystal grain of a publication, or the manufacture approach of a thin film 2 either.
[0017] The invention in this application concerning claim 4 is characterized by above-mentioned claim 1 or said bias voltage impressed in the semi-conductor crystal grain of a publication or the manufacture approach of a thin film being either of the pulse voltages which repeat a direct current, a pulsating flow, an alternating current, or positive/negative by turns 2 either.
[0018] The invention in this application concerning claim 5 is characterized by overlapping said bias voltage which consists of a pulse voltage which repeats a pulsating flow, an alternating current, or positive/negative by turns on direct-current bias voltage in the semi-conductor crystal grain of the claim 4 above-mentioned publication, or the manufacture approach of a thin film.
[0019] The invention in this application concerning claim 6 is characterized by including above-mentioned claim 1 or the process which forms the semiconducting crystal, the crystal grain, or the thin film of gallium phosphorus selectively on said semiconductor region in the semi-conductor crystal grain of a publication, or the manufacture approach of a thin film, and the process which some [at least] Lynn of this gallium phosphorus is permuted [process] by nitrogen, and deposits the crystal grain or the thin film of gallium nitride on the semiconducting crystal of said gallium phosphorus, crystal grain, or a thin film 2 either.
[0020]
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[Embodiment of the Invention] The case where a diamond, silicon carbide, gallium phosphorus, and gallium nitride are grown up on a single crystal silicon substrate is hereafter taken for an example, and the gestalt of operation of this invention is explained. First, 200nm of nitrides 2 is formed by the plasma-CVD method on the single crystal silicon substrate 1. Next, with the usual HOTORISO graphic method, it forms at intervals of a request of the nitride of 1-micrometer angle. As an example, patterning is carried out so that single crystal silicon substrate 1 front face may be exposed in the shape of a grid by 4-micrometer width of face. Next, at the wet oxidation furnace used by the production process of the usual semiconductor device, single crystal silicon substrate 1 front face to expose is oxidized, and silicon oxide 3 is formed. While silicon oxide 3 grows perpendicularly in a field without a nitride 2, at the edge of a nitride 2, it grows up to be the interior from the interface of the single crystal silicon substrate 1 and a nitride 2, and the so-called BAZU beak is formed (drawing 1).

[0021] Thus, by forming a BAZU beak, it can imprint to the pattern which reduced the pattern formed by the nitride. When temperature of a wet oxidation furnace is made into 1100 degrees C and oxidization of 5 hours is performed as an example, 0.4 micrometers of BAZU beaks grow. Consequently, the single-crystal-silicon field (a semiconductor region 4 is only called hereafter) with a diameter of 0.2 micrometers which does not oxidize will be formed directly under a nitride 2. Etching clearance of the nitride 2 is carried out with a heat phosphoric acid, a semiconductor region 4 is exposed, and a single crystal grain or a thin film is formed on this semiconductor region 4.

[0022] In addition, the silicon oxide 3 formed as mentioned above serves as a configuration which projected from the front face of a semiconductor region 4. Therefore, when it is desirable to carry out flattening when forming a single crystal thin film, flattening is performed as follows. First, a photoresist 5 is thickly formed in single crystal silicon substrate 1 front face in which silicon oxide 3 was formed (drawing 2 R> 2). After that. Etchback is carried out to a photoresist 5 on the etching conditions which do not have a difference in the etch rate of silicon oxide 3. Consequently, etching clearance of the projecting silicon oxide 3 is carried out, and silicon oxide 3 front face and semiconductor region 4 front face can form on the same field (drawing 3). Hereafter, the above-mentioned explanation explains the case where a single crystal thin film etc. is formed on the semiconductor region 4 divided by the silicon oxide 3 which has not carried out flattening.

[0023] Next, the microwave plasma CVD system used for this invention is explained. As shown in drawing 4 , the up electrode 8 and the lower electrode 7 are installed in a coil 6, and the single crystal silicon substrate 1 in which the semiconductor region 4 was formed on the lower electrode 7 is laid. DC power supply 9 are connected between the up electrode 8 and the lower electrode 7, and bias voltage, such as a direct current, a pulsating flow, and an alternating current, is impressed between two electrodes.

[0024] Vacuum suction of the inside of a coil 6 is once carried out with a pump, and reactant gas is introduced after that. After adjusting within a reaction to a desired pressure, bias voltage is impressed between the up electrode 8 and the lower electrode 7. The microwave supplied from the microwave power source 10 is simultaneously combined with reactant gas, and the plasma is generated. Such an approach is an approach called the so-called bias method. The case where the crystal grain or the thin film of a diamond, silicon carbide, gallium phosphorus, and gallium

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nitride is formed is hereafter taken for an example, and it explains to a detail.

[0025] (Diamond) The single crystal silicon substrate of the structure which has not carried out flattening of the silicon oxide 3 is first laid on the lower electrode 7 in a coil 6. Vacuum suction of the reaction within the pipe one is carried out to a 10-3torr base with a rotary pump. Then, hydrogen gas is introduced within a reaction, microwave power is switched on 700W, and the plasma is made to generate. At this time, the single crystal silicon substrate 1 is heated at 800 degrees C. By holding for 30 minutes in this condition, the natural oxidation film which grew up to be a semiconductor region front face is removed.

[0026] Next, hydrogen gas is introduced into 100sccm(s), methane is introduced in 1sccm and a coil 6, and plasma treatment is carried out from 90 minutes for 120 minutes. A semiconductor region front face is carbonized by this processing, and the carbonization layer 11 is formed of it (drawing 5). Next, the flow rate of methane is made to increase to 5sccm(s), and direct current voltage is impressed between the up electrode 8 and the lower electrode 7. At this time, a polarity uses as a negative electrode the lower electrode which lays a single crystal silicon substrate, and uses an up electrode as a positive electrode.

[0027] By impressing direct current voltage, the hydrocarbon ion charged in forward [which was ionized in the plasma] accelerates, and a single crystal silicon substrate is reached. Since, as for the single crystal silicon substrate surface, the most is covered with the oxide film, the ion current flows into a semiconductor region. At this time, the diamond layer to which bias conditions will consist of a microcrystal of a diamond in 5 - 15 minutes on applied voltage +100 - the +300 carbonization layer 11 of semiconductor region 4 front face which is not covered with an oxide film if it is V and 10-30mA of currents is generated. If epitaxial growth is continued by using this diamond layer as a nucleus, the diamond thin film 12 will be obtained (drawing 6).

[0028] The crystal orientation of the microcrystal of the generated diamond and a diamond thin film is in agreement with field bearing of a single crystal silicon substrate surface. When a single crystal silicon substrate surface is a field (100), orientation of the diamond formed is carried out to a field (100). (100) Make hydrogen gas and methane into (a methane flow rate / less than [hydrogen quantity-of-gas-flow (please check) =0.1%]), and make a field they carry out epitaxial growth to the nucleus which carried out orientation for about 2 hours. Consequently, crystal grain with a diameter of 0.7 micrometers was able to be obtained.

[0029] The SEM photograph of the crystal grain formed in drawing 7 is shown. It turns out that crystal grain is growing selectively on the semiconductor region divided by silicon oxide. Therefore, in case this invention forms a diamond on the substrate of the diameter of macrostomia conventionally, it has the advantage that the origination of nucleus which was not able to be controlled is controllable.

[0030] When the crystal orientation of a single crystal silicon substrate surface is a field (111), orientation of the diamond formed is carried out to a field (111). (111) The diamond which uses a field as the maximum top face grows epitaxially with breadth in a longitudinal direction to a substrate top face. Consequently, it becomes possible about a substrate front face to form a wrap thin film. If a thin film is formed from the nucleus generated to the field which was divided with the oxide film like this invention, and where area is dramatically small, the comparatively big single crystal film can be obtained from one nucleus. Therefore, compared with the conventional polycrystal film, it becomes possible to obtain the single crystal film with few defects.

[0031] Furthermore, when a single crystal silicon substrate surface is a field (110),

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orientation of the diamond formed is carried out to a field (110). (110) Epitaxial growth can progress in the direction of a field (111), and the diamond which uses a field as the maximum top face can obtain the crystal of a rectangular parallelepiped. By meaning and controlling this growth direction, it becomes possible to realize optical waveguide and a microwave circuit like minute device components with crystal growth.
[0032] Since the reactant gas at the time of forming a diamond is not limited to the above-mentioned hydrogen gas and methane, and the rate of crystal growth is controlled or it prevents generating of side **, it can also add oxygen if needed.
[0033] (Silicon carbide) Next, the manufacture approach of silicon carbide crystal grain or a thin film is explained. 50nm of nickel film 13 is formed in a single crystal silicon substrate surface with electric-field plating. 900 degrees C and heat treatment for 2 minutes are performed to this single crystal silicon substrate. Consequently, the silicon and nickel of a semiconductor region react and the nickel silicide layer 14 is formed in a semiconductor region front face (drawing 8). A FUTSU nitric acid removes unreacted nickel.
[0034] Next, it lays on the lower electrode 7 in the coil 6 of the equipment which shows the single crystal silicon substrate 1 in which the nickel silicide layer 14 was formed on the semiconductor region front face to drawing 4 . Vacuum suction of the reaction within the pipe one is carried out to a 10-3torr base with a rotary pump. Then, reactant gas 2sccm containing the carbon diluted with hydrogen gas to about 1%, such as methane and ethane gas, is introduced in a coil 6, microwave power is switched on 600W, and the plasma is made to generate. At this time, the single crystal silicon substrate 1 is heated at 800 degrees C, and bias is impressed on the conditions from which a current is set to 10-30mA. By holding for 5 - 15 minutes in this condition, the nickel silicide layer 14 formed previously turns into a lifting and the silicon carbide layer 15 containing the microcrystal of silicon carbide in the carbon which reactant gas, such as methane, disassembled and generated, and a substitution reaction (drawing 9). A silicon carbide microcrystal should just make some nickel of a nickel silicide layer front face permute by silicon carbide at least here that it does not necessarily need to be formed all over a semiconductor region, and it becomes a nucleus and extent formation should just be carried out.
[0035] Here, if methane etc. is diluted and supplied with hydrogen gas, a thick silicon carbide crystal can be deposited rather than it supplies by the gas independent containing carbon.
[0036] Next, a FUTSU nitric acid removes selectively the nickel which deposited by the substitution reaction. The single crystal silicon substrate 1 by which the silicon carbide layer 15 was formed in the semiconductor region front face is again laid on the lower electrode 7 in the coil 6 of the equipment shown in drawing 4 . Vacuum suction of the inside of a coil 6 is carried out to a 10-3torr base with a rotary pump. Then, at silane 0.04mol% and butane 0.02mol%, it can introduce in a coil 6 and the silicon carbide thin film 16 can be obtained (drawing 10).
[0037] According to such an approach, the silicon carbide layer 15 acts as a buffer coat, and eases about 13% of mismatch of the lattice constant (5.43A) of silicon, and the lattice constant (4.51A) of silicon carbide, and it becomes possible to obtain the silicon carbide thin film of high quality with little distortion. Moreover, in order to form a thin film by using as a nucleus the silicon carbide microcrystal generated to the field which was divided with the oxide film like this invention, and where area is dramatically small, the comparatively big single crystal film can be obtained from few nuclei, and also when a crystal carries out overgrowth and collides, an anti FAIZU boundary is not
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produced. Therefore, compared with the conventional polycrystal film, it becomes possible to obtain a single crystal thin film with few defects.

[0038] Moreover, since the crystal structure serves as 3C (cubic), the electronic mobility of the silicon carbide grown up at the above-mentioned temperature (1400 degrees C) is larger than 1000cm2/V-sec and 6H (hexagonal), and the property which was excellent as an ingredient of an electron device is shown.

[0039] Although the case where nickel was permuted by carbon was explained after the above explanation having formed nickel on the semiconductor region and forming nickel silicide, this invention is not limited to nickel. For example, instead of nickel, you may be titanium, chromium, manganese, iron, cobalt, molybdenum, and a tungsten.

[0040] (Gallium phosphorus) Next, the manufacture approach of gallium phosphorus crystal grain or a thin film is explained. First, it lays on the lower electrode 7 in the coil 6 of the equipment which shows a single crystal silicon substrate to drawing 4 . Vacuum suction of the inside of a coil 6 is carried out to a 10-3torr base with a rotary pump. Then, hydrogen gas is introduced in a coil 6, microwave power is switched on 800W, and the plasma is made to generate. At this time, the single crystal silicon substrate 1 is heated at 700 degrees C. By holding for 30 minutes in this condition, the natural oxidation film which grew up to be a front face is removed.

[0041] Next, introducing the reactant gas which consists of a gallium chloride and phosphoretted hydrogen in a coil 6, and impressing bias voltage between the up electrode 8 and the lower electrode 7, microwave power is switched on 700W and the plasma is made to generate. At this time, the single crystal silicon substrate 1 is heated at 800 degrees C. It holds for 10 minutes in this condition.

[0042] Here, mass is 69.72 and 30.97, respectively and the mass difference of a gallium atom and the Lynn atom is large. Therefore, in order to make the gallium phosphorus (GaP) of stoichiometric composition deposit, fixed direct current voltage is not impressed but the pulse voltage to which potential is regularly changed to positive/negative is impressed. Consequently, when the lower electrode is a negative electrode, gallium ion arrives at a semiconductor region front face, and when the lower electrode is a positive electrode, phosphorus ion reaches. In consideration of the mass difference of gallium ion and phosphorus ion, pulse width, applied voltage, etc. are set up suitably. When the gallium phosphorus layer 17 which contains the microcrystal of gallium phosphorus by being referred to as applied-voltage**100V, making into 20 seconds pulse width of the bias to which phosphorus ion arrives at a substrate front face, making into 10 seconds as an example pulse width of the bias to which a gallium arrives at a substrate front face, changing a polarity, and repeating 20 times was formed on the semiconductor region and continued growth further, it has checked that the gallium phosphorus thin film 18 was formed (drawing 11).

[0043] The approaches of impression of bias voltage may be a pulsating flow and an alternating current. Moreover, it is also possible to set up so that the electrical potential differences which superimposed direct current voltage, i.e., the electrical-potential-difference value impressed with the polar sense, may differ. In this case, a wave-like part is transferred to a negative side, and it is necessary to set up so that a polarity may be reversed.

[0044] Moreover, the reactant gas introduced in a coil 6 is made into a gallium steam instead of a gallium chloride, and is good also as mixed gas of a phosphorous chloride and hydrogen instead of phosphoretted hydrogen.

[0045] (Gallium nitride) The manufacture approach of gallium nitride crystal grain or a thin film is explained below. It lays in the equipment which shows the single crystal

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silicon substrate 1 in which the gallium phosphorus film 17 formed by the above-mentioned approach was formed to drawing 4 . Vacuum suction of the reaction within the pipe one is carried out to a 6x10-2torr base with a rotary pump. Then, ammonia gas is introduced within a reaction, microwave power is switched on 700W, and the plasma is made to generate. At this time, the single crystal silicon substrate 1 is heated at 800 degrees C. By holding for 10 minutes in this condition, the substitution reaction of nitrogen and a gallium occurs and the gallium nitride layer 19 is formed in the front face of the gallium phosphorus thin film 18. This has the standard enthalpy of formation of gallium nitride as small as -24.9 kcal/mol to the standard enthalpy of formation of gallium phosphorus being -17.2 kcal/mol, and is because the direction of gallium nitride is the more stable matter.

[0046] The approach of making permute Lynn, gallium phosphorus, by nitrogen, and generating gallium nitride makes not only the above-mentioned approach but the reactant gas which contains nitrogen at least plasma-ize, and the approach of contacting a gallium phosphorus thin film to the plasma, the approach of heating in the reactant gas which contains ammonia gas at least, etc. are possible for changing variously.

[0047] Thus, the mixed gas of gallium chloride (GaCl3) partial pressure 4torr and nitrogen (NH3) partial pressure 200torr is introduced in a coil 6 by full-flow 3800sccm by using the generated gallium nitride layer 19 as a nucleus, using hydrogen as carrier gas. If the single crystal silicon substrate 1 is heated at 1000 degrees C at this time, the cubic gallium nitride thin film 20 will grow epitaxially (drawing 12).

[0048] Thus, since very near gallium phosphorus is formed with the lattice constant of silicon on the single crystal silicon substrate, the curvature of a substrate and the substrate by the difference of the lattice constant of gallium nitride etc. cannot produce the formed gallium nitride thin film easily.

[0049] As mentioned above, although the case where the crystal grain or the thin film of a diamond, silicon carbide, gallium phosphorus, and gallium nitride was formed on a semiconductor region was explained, this invention is not necessarily limited to these semi-conductors. It is possible to form the desired crystal grain or the desired thin film of a semi-conductor according to the ionization energy of the source material of a semiconducting crystal and mass by setting up suitably the value of bias voltage, a pulse or the amplitude of alternating voltage, a period, and duty.

[0050] moreover, the inside of the plasma ambient atmosphere excited by microwave not necessarily when forming a diamond thin film, a silicon carbide thin film, a gallium phosphorus thin film, and a gallium nitride thin film -- epitaxial growth -- it is not necessary to carry out -- MBE -- it is good also by law.

[0051]

[Effect of the Invention] as explained above, in order to form a semiconductor region by selective oxidation according to this invention -- photograph RISOGURAFU of high performance -- since it is not necessary to use law, it is possible to produce the substrate which has a semiconductor region with cheaply and sufficient repeatability.

[0052] Since the semiconductor region is divided by silicon oxide, when bias voltage is impressed, it is possible for the ion current to flow only into a semiconductor region and to form a crystal growth nucleus selectively and effectively.

[0053] Since it is the cubic system which carried out orientation and the low defective film can be formed in field bearing of a silicon substrate when forming a diamond by this invention, it is possible to form the substrate of the property which was excellent as an electron device ingredient.

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[0054] Since it is growing up from the crystalline germ generated to the semiconductor region divided by silicon oxide when forming silicon carbide by this invention, it is possible to be hard to produce the curvature by the difference of the lattice constant of a single crystal silicon substrate and the grown-up silicon carbide thin film etc., and to form the substrate of the diameter of macrostomia cheaply.

[0055] Since very near gallium phosphorus is formed with the lattice constant of silicon on a single crystal silicon substrate and gallium nitride is formed on it when forming gallium nitride by this invention, it is possible to be hard to produce the curvature by the difference of the lattice constant of a single crystal silicon substrate and gallium nitride etc., and to form the substrate of the diameter of macrostomia cheaply.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the explanatory view of the process which forms the semiconductor region of this invention.
[Drawing 2] It is the explanatory view of the process which forms the semiconductor region of this invention.
[Drawing 3] It is the explanatory view of the process which forms the semiconductor region of this invention.
[Drawing 4] It is the explanatory view of the microwave plasma CVD system used for this invention.
[Drawing 5] It is the explanatory view of the process which forms the diamond thin film of this invention.
[Drawing 6] It is the explanatory view of the process which forms the diamond thin film of this invention.
[Drawing 7] It is the SEM photograph of the diamond crystal grain of this invention.
[Drawing 8] It is the explanatory view of the process which forms the silicon carbide thin film of this invention.
[Drawing 9] It is the explanatory view of the process which forms the silicon carbide thin film of this invention.
[Drawing 10] It is the explanatory view of the process which forms the silicon carbide thin film of this invention.
[Drawing 11] It is the explanatory view of the process which forms the gallium phosphorus thin film of this invention.
[Drawing 12] It is the explanatory view of the process which forms the gallium nitride

thin film of this invention.
[Drawing 13] It is the explanatory view of the process which forms the conventional diamond thin film.

[Description of Notations]
1 Single Crystal Silicon Substrate
2 Nitride
3 Silicon Oxide
4 Semiconductor Region
5 Photoresist
6 Coil
7 Lower Electrode
8 Up Electrode
9 DC Power Supply
10 Microwave Power Source
11 Carbonization Layer
12 Diamond Thin Film
13 Nickel Film
14 Nickel Silicide
15 Silicon Carbide Layer
16 Silicon Carbide Thin Film
17 Gallium Phosphorus Layer
18 Gallium Phosphorus Thin Film
19 Gallium Nitride Layer
20 Gallium Nitride Thin Film
21 Semi-conductor Substrate
22 Nucleus
23 Thin Film

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]

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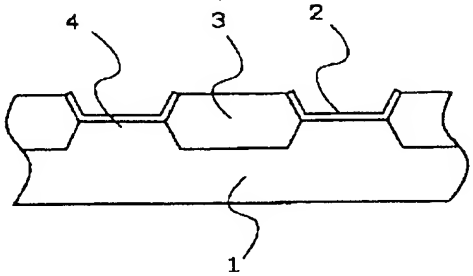
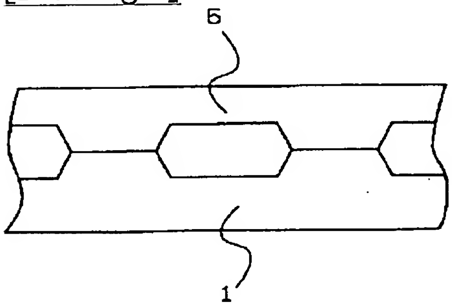
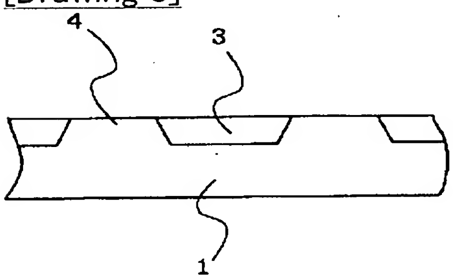


[Drawing 2]



[Drawing 3]



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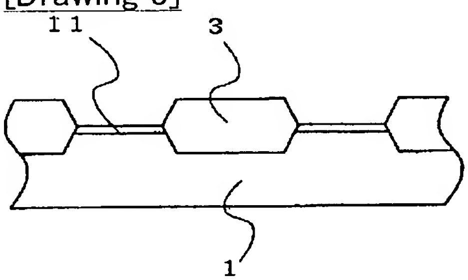

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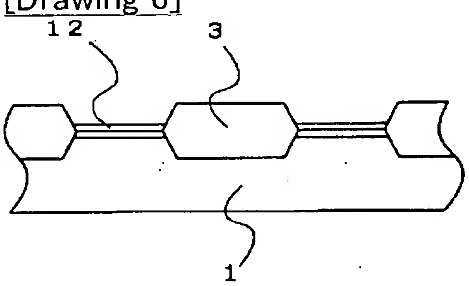

[Drawing 7]

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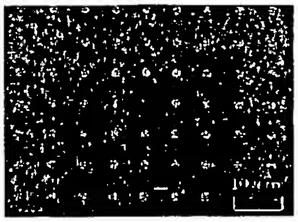
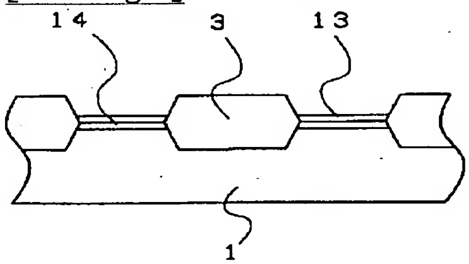
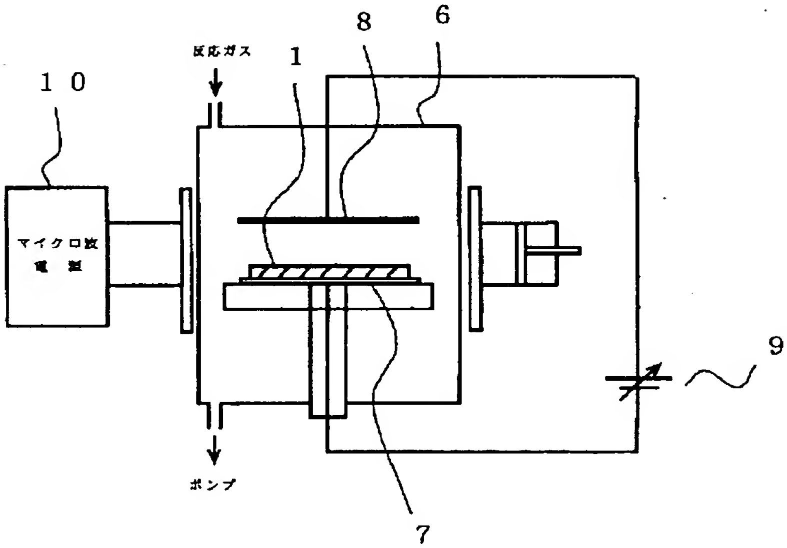


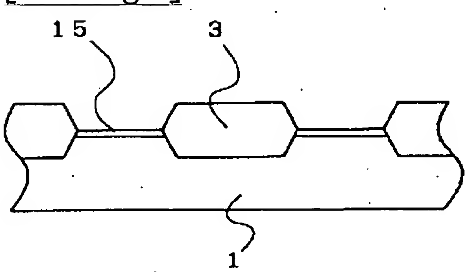
[Drawing 8]



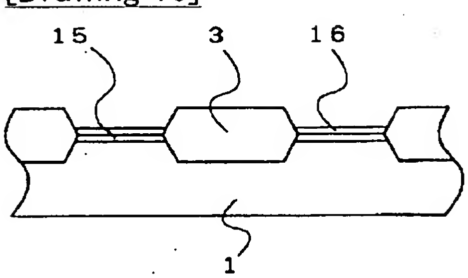
[Drawing 4]



[Drawing 9]



[Drawing 10]



[Drawing 11]

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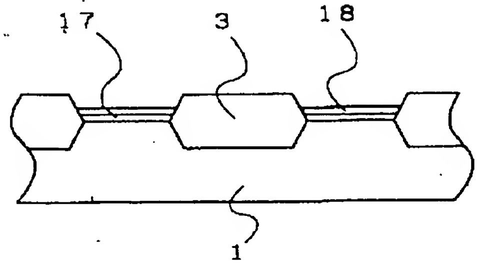
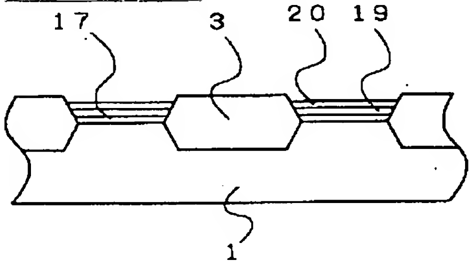
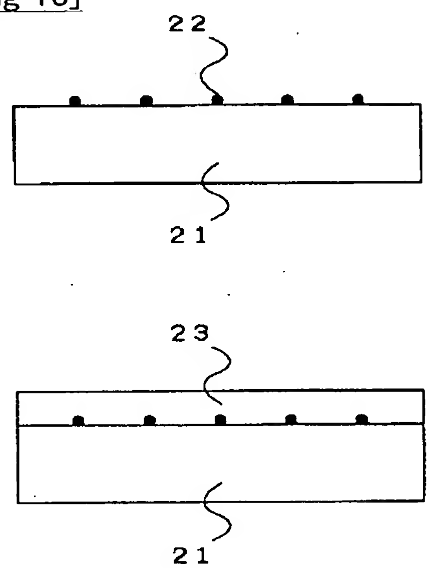


[Drawing 12]



[Drawing 13]



(a)

(b)

[Translation done.]

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